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RESULTS AND EXPECTATIONS OF RESEARCH ON FISHERY PROBLEMS

By Dr. PHILIP H. MITCHELL

U. S. BUREAU OF FISHERIES AND BROWN UNIVERSITY

TO speak of calories in the days before this war was to be outlawed as a conversationalist. Now the word is in the vocabulary of every housewife and even at the club or hotel you may hear men grumbling that they are fed on calories. With equal certainty we note the popular adoption of the scientific lingo of the engineer, the chemist and the statistician. In strenuous war times the people turn to science with renewed interest and confidence. They even submit humbly and expectantly to scientific dictation. It is hard to imagine the American public in peace times submitting to the admonition, "Eat more fish instead of meat," no matter how many statisticians might recommend it. Yet that slogan is warmly received now. Sometimes the public confidence in the victorious power of science is almost pathetic, as in the case of a hope for a submarine panacea. In the Utopian republic respect and confidence toward science would be based on knowledge of its power and progress and neither distrust nor overconfidence would hamper the usefulness of scientific results. That happy state does not exist, so that science should still take pains to make clear to the laity why research has produced and will produce results of benefit to humanity. During this wave of sympathy with science it is timely to show the justification for the expenditure of government funds and private endowments for scientific research and to state some of the needs for the future.

Results and hopes of any one of our large and productive laboratories in state or endowed universities or in research institutions would alone give a fitting exposition of the human usefulness of research. With equal propriety one might choose the work of any or all of our government bureaus. My own experience gives me opportunity to know some of the results and aims of the United States Bureau of Fisheries. The description of the scientific work does not pretend to completeness or any sort of cataloguing, but merely to presentation of a background for the suggestion of possible lines of future effort. There is no intent to imply that the Bureau has announced its purpose to pursue the problems here stated. They are merely the problems which through conference with various members of the bureau's staff and through my own researches have come to my attention. They are taken from all portions of the field of biology.

General biological surveys and intensive observations of the flora and fauna of waters in restricted areas have proved their usefulness. Of course much of the work of that character has served to locate fishing grounds. In some cases an abundance of fish of certain species not previously used could be pointed out. For example, the biological surveys of the continental shelf of our Atlantic seacoast revealed the presence of tilefish. Subsequent observations, extending over a period of years, made it possible to record their catastrophic decrease in numbers followed by their slow increase, so that when fishermen were persuaded to go after tilefish abundant schools were found at once. Within two years after the first shipload of tilefish was brought into port the supply in the markets of New York and Boston amounted to nine millions pounds annually. This constitutes a real addition to our food supplies. Biological surveys show so great an abundance of the species, extending over so large a habitat that fishing activities are not likely to deplete them. Barring unpredictable circumstances tilefish should be a staple commodity in our markets. Similar results may be expected from surveys locating beds of sea-mussels. Though treated as a great delicacy by European culinary art the mussel has not been appreciated here. A demand, stimulated chiefly through the efforts of the Bureau of Fisheries, is being created. Extensive beds located in many of our coastal waters are being mapped out. They could yield a satisfactory supply. If this knowledge were used to good advantage by the shell-fisheries industry another important addition to our food resources would be made. At this time, when clam digging has in so many communities been worked almost to the extinction of the clam and when the oyster industry is complaining that many of their most productive waters are no longer available for oyster culture because of pollution, we must find some means of increasing our supply of edible shell-fish. While efforts are directed toward the development of improved methods of clam and oyster culture, we must also avail ourselves of the ocean's munificent supply of sea-mussels. A slightly different type of useful result is seen in the introduction of the manufacture of ornamental "artificial ferns" from marine hydroids. A knowledge of the location of these growths made it possible to build up a considerable industry.

These three examples are selected from many which might show the value of biological surveys as carried out in marine investigations. As a matter of fact, the vast resources of the ocean have scarcely been touched. The more we can know about them the better shall we make use of them. Some of the specific problems of this type that are awaiting investigation include the determination of the causes of fish migration, of the abundance of certain species during certain years, of the scarcity of some species during longer or shorter periods over areas sometimes very large. Why should mackerel be so marvelously abundant for a few years during the '80s and then be comparatively scarce for nearly thirty years, reappearing again in huge schools all along our New England coast? Similar variations in the abundance of many of our common fishes are on record. We ought to know whether they are due to changes in food supply, to meteorological conditions, to fluctuations in ocean currents, to fish diseases, to variations in the suitability of breeding conditions, or to other causes. Extensive oceanographic observations, especially biological surveys, including a study of the ultimate sources of the food of fishes and the distribution of many species at different seasons must be made. Since the higher forms live at the expense of the lower ones explanations of the food supply of fishes must include a study of the microscopic life of the sea. It seems probable that bacteria and diatoms, those minute vegetative forms so generally abundant, are really the ultimate feeders for life in the sea. It is perhaps difficult for the casual observer to realize that filtering specimens of sea water day after day and month after month would yield material important in determining the migrations of fishes, but such observations to show the distribution of diatoms will in all probability help to solve the question of the distribution of all life in the sea. Not only the microscopic plants, but seaweeds, seem to possess fundamental importance in maintaining a supply of nutrition for marine fauna. To what extent the various common seaweeds play a significant rôle in what might be called the metabolism of the sea, remains to be determined.

Even compared to such general biological survey work, intensive studies in comparative anatomy and morphology have also yielded and will continue to yield significant results. Consider, for example, the importance of studies on the life history of the oyster. They have made possible the development of modern methods of oyster culture, an industry more highly developed in America than in any other country. Much remains to be done to fill the gaps in our formation. What conditions are responsible for the failure to obtain during certain seasons a "set" of young oysters? Why were seed oysters once abundant in certain localities which do not now produce them? To what extent do oysters lend themselves to artificial hatching, so that the present occasional discouraging failures in the seed crop may be obviated? These are still among the unsolved problems of oyster culture now receiving earnest attention. It would not have been possible to attack them unless knowledge of the morphology and life history of the oyster were far advanced. Similar information on the developmental history of the clams and mussels is available. Its application to clam culture is just beginning and will no doubt become more important in the not distant future. The cultivation of sea-mussels is still an unknown art but when they are known for the delectable food they are, sea-mussel growing may also become an applied science. The story of the fresh-water mussel, how it is reproduced, how it becomes parasitic on the gills of certain species of fish, and while growing there is transported to a new habitat, how it then drops off, becomes "planted" and develops to furnish an article of great commercial value as the basis of the pearl button industry—all this constitutes one of the most interesting chapters in biology. It is a striking instance of the development and application of morphological investigation. Further work on the optimum conditions for reproduction, on the kinds of fishes which may serve as hosts during the parasitic period, and on other similar problems is going forward.

The developmental history of the lobster has been of equally striking use. A knowledge of the different molting stages through which the young lobsters pass made possible the devising of special cultural methods for rearing lobsters to a stage at which they are able to escape their enemies, hide beneath rocks, and, in short, take care of themselves. Artificially hatched lobsters reared to this stage may be liberated with some hope that thereby the depleted supply of this table luxury will be increased. Such researches on invertebrates, interesting as they are, seem small in the importance of their food productive results alongside the embryological and anatomical studies of food fishes. These are the basis of all fresh- and salt-water hatchery work. Future extensions of such activities will require amplification of our knowledge of the developmental history of many species.

Studies in fish pathology contribute their share to the success of fisheries. Here perhaps in better measure than elsewhere are shown unexpected application of research supposed to be in pure science without practical usefulness. Long-continued observations on the occurrence of various species of parasites in a number of common food fishes made it possible to distinguish the harmlessness to human beings of certain of the parasites. When, therefore, health authorities of the city of New York, alarmed at the discovery of parasites in butterfish, seized so many of them in the fish markets that an estimated loss of $30,000 occurred within three days, the bureau was able to furnish decisive information. The parasites had been proved to be harmless and to have been present in a large proportion of butterfish as examined over a period of many years. The sale of these fish was therefore continued and a large food loss prevented. This is one instance. Other similar cases have occurred. A complete knowledge of the parasitology of fishes is desirable from the standpoint of safeguarding human food, but the application of this knowledge should not stop there. Fish pathology should be able to furnish information helpful in the work of increasing our supply of fish. It has been shown that some loss of food fishes certainly occurs as the result of parasitism and other fish diseases. The cure and prevention of infections in a number of kinds of fishes, notably those, like trout, occurring in limited bodies of water, has been possible. An almost unlimited field remains to be developed here for marine fishes. We have little idea as to what extent disease is a cause of their depletion. The nature and the prevalence of such diseases, the life histories of parasites, whether bacterial, protozoan or of other nature, must be worked out much more fully than has been done to date. With such information available it is to be hoped that means of control might be devised.

The work which the biochemist may do for the solution of fishery problems covers a varied field. The metabolism of aquatic forms has received some attention. The application of that knowledge to the maintenance of proper nutrition in fishes artificially reared and of suitable oxygen supplies in the water of fish hatcheries has been useful. If this country is to adopt, as prudence strongly advises, a more extended custom of rearing fish domestically in small ponds all the problems relating to the most economical and effective methods of nourishing fish in confined waters must receive more attention than they have had. The need of information about the physiology of nutrition of a specific aquatic form has already been emphasized. I refer to the oyster. It was formerly possible to obtain oysters in a well-nourished condition, the so-called "fat" oysters, so as to supply the market adequately. The best nourishment for oysters, however, is found in those brackish waters around which growing population now tends to furnish pollution. Oyster beds have been forced further and further away in many localities from the best feeding grounds and successful oyster culture has become more difficult. Transplantation of stock to good feeding grounds has to be resorted to, the latter are overcrowded and the production of really well-nourished oysters is diminished. Oyster culture in certain European localities has come to the use of rapid, forced "fattening" in small ponds. The most efficient application of any such method can only be based on a knowledge of many possible foods for the oyster and a well-developed study of its metabolism. Such investigations have been fostered by the bureau for some years and need to be further extended. Knowledge of the nutritional processes in a few marine organisms will throw at least some light on similar problems connected with others and surely the metabolic histories of all forms which may be artificially reared will have their practical significance.

The work of the specialist in dietetics is required in fishery problems. Since the early work of Atwater on the composition of American food materials, including extensive studies of fish and shell-fish, very little has been done to determine the food value of fishery products. In recent years our ideas of real food requirements have been radically revised. We no longer speak merely of the protein requirements of the body. We distinguish relatively great differences in the food value of the proteins from different sources. These distinctions can best be made in accordance with technique now developed by elaborate and well-controlled feeding experiments. Food values, in short, have to be determined biologically. Almost no work of this sort has been carried on with the proteins of fish and shell-fish. We desire to avail ourselves as far as possible of the comparatively inexhaustible food resources in the ocean. Particularly do we hope to supplement our expensive proteins, replacing meats, in some measure at least, with fish. To what extent we should do that depends properly upon the relative food value for human beings of fish proteins compared with others. A similar problem in nutrition is the vitamine content and the presence of various metabolism catalyzers in fishery products. It has been stated, though not yet perhaps entirely proved, that cooked foods no longer contain the so-called vitamines which might be present in the raw product. This idea together with the seemingly established fact that vitamines are commonly present in animal tissues has led to claims which need to be substantiated. For example a more extended consumption of raw oysters has been recommended. That this may be sound advice and that we may thus healthfully increase our ingestion of vitamines is perhaps true, but it ought to be proved. Similar investigations of many foods await, to be sure, an attack, but for none of them would the usefulness of results seem more immediate than in the case of fishery products. Nowhere else is there available so great a store of food from animal sources immediately and comparatively cheaply accessible. The tremendously valuable work on the general nutritional value and limitations of some of our great food staples, like the cereals and the dairy products, as it has been carried on by certain of the physiological laboratories of this country should soon be followed by similar studies on fish and shell-fish.

Investigations in industrial chemistry occupy by no means a minor field among fishery problems. The manufacture of fish glue, the best methods for the preparation of fish fertilizers, the manufacture and industrial utilization of a great variety of fish oils, the preparation of potash and other potassium salts, of iodine and bromine from giant kelp and other sea-weeds are among the well-known chemical engineering attainments concerned with marine products. In the present world-wide shortage of hides the utilization of various fish skins in the tanning industry has of late received considerable attention from the Bureau of Fisheries. Future developments of these efforts will no doubt be observed with considerable interest. In this group of industrial problems, however, much remains to be accomplished. One has only to observe the large amount of waste in the form of fish offal now discarded from the receiving docks of any fisheries establishment to realize that we have a long way to go before we reach true conservation. To what extent the organs of fishes may be capable of yielding internal secretions or other preparations of therapeutic value remains to be shown. Better salvage of fats and the preparation of fertilizing material by more economical methods are perhaps to be developed in the future.

Appreciated only by those having the true research spirit is the fact that the more fundamental the research problem solved, the larger the number of practical difficulties solved by it. Any fool can see what a knowledge of the laws of electricity means to the modern world, but it took the genius of a Franklin to prophesy the importance of electrical research in its early days.

Countless illustrations of practical applications of scientific knowledge are brought forward to show how science is justified in dollars and cents even if one refuses to justify it on the plea of satisfying the thirst for knowledge. The so-called "pure" scientist and the "practical" scientist no longer gibe each other. They have long since come to understand that the work of neither can attain its full significance for mankind without the other's aid. It would probably be extremely difficult to find a man who would like to classify himself exclusively as either a "pure" or a "practical" scientist. Indeed no one experiment or group of experiments constituting a single research, if conceived and carried out by a sane mind, is likely to be entirely lacking in either general scientific interest or practical human value—if only you can see the interest and value! Unfortunately a large proportion of the world does not. When once convinced they applaud, but they still demand to be shown the connection between research and life. That a study of surface tensions in an oil emulsion should reveal a method for the successful preparation of a delicious food out of a material that would otherwise be wasted is not easy to believe. A long jump of the imagination is required unless the intermediate steps are explained. It is simple enough. When various researchers had shown that a trace of sodium soap increased, by its surface tension effects, the permeability of tissues to water, it was to be expected that a very dilute soda solution forming a trace of soap in desiccated fish would enable it to soak up water rapidly enough to make possible the preparation in any kitchen of a delicious dish out of a decidedly unappetizing dried fish. Relationships of this kind as they appear out of a group of problems to one worker have been sketched in this paper. If one of the co-workers in every science laboratory or unit group of researchers would take the time and trouble to at least state what they believe they have accomplished and what they hope to do there might be on record a reliable answer to the questions of the interested public. This is being increasingly done in these days of the progressive magazines, but even yet information is still obtained too often through an irresponsible newspaper reporter—the modern personification of old dame rumor. If this paper makes clearer to any one the problems confronting fisheries research, or if it induces any workers to cooperate in the solution of them, its object is attained.